1.0 Executive Summary

"Parcel mapping is a contiguous process that should evolve toward increasing reliability and accuracy. These maps are never finished, and require constant updating to keep pace with cadastral transactions. Parcels are complex features. To determine the overall geometric relationships, ties to physical geography, and historical and legal objects must be considered. Even the definition of what constitutes a parcel often varies widely. It is important, however, to stress the importance and use of the parcel in the GIS environment. Though reliability, consistency, accuracy, and precision are all important attributes of a parcel map, they should still be considered only a model of the physical and legal world, and not an exact replica."

James G. Donahue, PLS. Cadastral Mapping for GIS/LIS. ASPRS/ACSM, 1994. Copyright ASPRS/ACSM

1.1 Purpose of the Document

The purpose of this document is to provide for the extensive review of the National Integrated Land System (NILS) Concept of Operations and User Requirements by the NILS partners and others involved with the cadastral land records. Meetings are being held in Portland, OR, Phoenix, AZ, Denver, CO, Atlanta, GA and Washington, D.C. to facilitate this review. Copies of the document are also available via the Bureau of Land Management (BLM) web page at **www.blm.gov/nil**s and the comment period is from November 29, 1999 until January 15, 2000.

NILS is an initiative to provide a business process method to collect, maintain, and store parcel-based information that meets the needs of the widest possible spectrum of land title and resource information providers and customers. NILS is being managed in a partnership environment. The primary partners are BLM, the U.S. Forest Service (USFS), states, counties and private industry.

A list of participants is included in Appendix B. In addition, NILS has an advisory group, called the Parcel Consortium, which includes BLM, Forest Service, Environmental Systems Research Institute (ESRI), Oakland County, MI and Fairview Industries.

1.2 NILS

1.2.1 Vision and Scope

BLM is in the process of developing a bureau-wide architecture to provide the framework for all information technology investments. This framework includes conducting business process analysis for BLM's core business functions. The NILS Project is conducting the business process analysis for the core business functions for providing land and resource title information.

Specifically, the NILS project is an initiative to develop a common solution for BLM and the Forest Service and their partners for the business processes involved with the management of cadastral land records. Because these business processes have much in common with those of the larger survey and land management community and the BLM and Forest Service are committed to working in partnerships, the NILS project is a cooperative venture. NILS will implement the Federal Geographic Committee's Cadastral (FGDC) Data Content Standard, while contributing to the National Spatial Data Infrastructure (NSDI). NILS is being managed using the Managed Evolutionary Development (MED) methodology, which is a phased development process. An overview of this process is included in Section 6

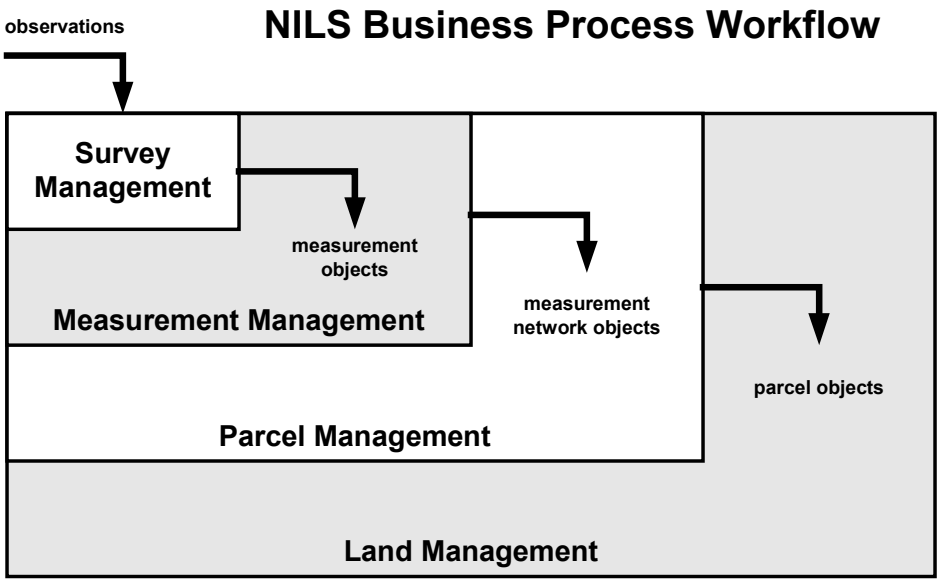
1.2.2 Field-to-Fabric Concept

A central goal of NILS is that users would have the tools to manage land records and cadastral data in a Field-to-Fabric manner. (See Figure 1.1.) This concept implies the fundamental goal of developing a common data model that unifies the worlds of Surveying and Geographic Information Systems (GIS). This unification concept is fundamental for land records managers and maintainers of cadastral mapping databases as they strive to improve the accuracy and quality of their data.

One prevailing pattern in the management of land records and cadastral data is that the accuracy of maps can be enhanced using new data acquired by more accurate techniques. As new surveys translate into legal descriptions and subdivision plats, map maintainers can use these new measurements as a source of control for their maps. The professional community of land surveyors and land records managers require better tools to find and extract data from a GIS, to use that data to prepare for and to complete a field survey, and to incorporate the new survey data as improved control to enhance the GIS.

The geographic representation of cadastral data is often managed as a series of maps (e.g. assessor map books, master title plats). Using GIS tools, these maps may be automated (digitally converted) and managed in a digital drawing environment. When map layers are used to manage the geometry/geography of cadastral features like parcels, the individual features in the map layer should share geometry without gap or overlap. A **fabric** refers to a map layer of features that share geometry at nodes (corners) and edges (boundaries) in a seamless topological structure. When features in a fabric are edited, a change to a geometric element (i.e. a point, line or area feature) affects the shape of all features that are topologically tied to the edited feature.

Figure 1.1



1.2.3 Methodology

An object-oriented analysis and design (OOAD) method was used to capture the essential business process requirements that would be supported by the NILS software application.

The object-oriented approach, as it relates to the design and development of software applications, focuses on modeling the real-world entities that are involved in an integrated set of business processes. Essential business processes are identified, named and described as a system's use cases. Use cases serve as conceptual containers for the series of steps that are performed to complete a given workflow process. As the description of the use case becomes more detailed, a set of real-world actors, inputs, documents, forms, processes, interactions and outputs are identified. These process-related entities are 'candidates' for the types of software 'objects' that must be designed and developed. (See Section 5 for more detail on the OOAD method).

1.3 Business Process Overview

The NILS Project includes the business processes which involve the ability to provide land and resource title information.

The following is a brief description of the components of the NILS Project:

- Common Cadastral (land) Data Model data model built upon the FGDC Cadastral Content Standard, enhanced to meet the core functional requirements of the NILS partnerships. The model would contain feature object classes representing the properties, rules, and behaviors of cadastral entities, and designed as an open and extensible format to facilitate both generalization and customization.
- Field Survey Process: An integrated set of automation objects that are embedded into compatible survey data collection software packages to support the capture of

measurement features and metadata into a database format. The goal of the Field Survey Process is to minimize the need for data conversion and re-construction as measured features are incorporated into the land records management system.

- Measurement Management Process: Produce a new feature coordinate solution by performing a weighted planimetric-geodetic adjustment according to the qualitative characteristics of individual feature elements in the working set. Measurement Management Process enables users to create a higher-quality, control network database for the Public Land Survey System (PLSS) and the non-Rectangular Survey System (metes and bounds), relying upon much of the feature and functionality inherent in the GCDB Measurement Management system (GMM).
- Parcel Management Process: A process for managing land records and cadastral feature data stored in the database model, providing custom feature classes, tools, and procedures for editing land records in a transactional, history tracking environment. Users would be able to customize the Parcel Maintenance process to accommodate their established workflow and business processes.
- GeoCommunicator: An proactive Internet subscription process for sharing access to data stores and to planned and existing program project activities in cadastral and realty to facilitate collaborative capabilities and data sharing.

1.4 Overview of NILS Use Cases

The following section provide an overview of the use cases for each business process area.

1.4.1 Overview of Survey Management Use Cases

Concepts

The use cases for survey management (SM) are intended to describe the various business processes necessary to conduct field surveys in an automated GIS environment. An important aspect of any survey project is to research all available records for pertinent data. The first use case, ***SM-01 Survey Research***, is designed to assist in locating and evaluating survey and survey related records. The ***SM-02 Pre-Field Survey Setup*** use case guides a user through the necessary steps to prepare a data collection device (i.e. laptop or palmtop) for use in the field. This may include the transfer of reference data to the data collection device immediately or at a future time. The ***SM-02 Pre-Field Setup*** may occur on a data collection device or on a desktop personal computer for later transferal to the data collection device. The ***SM-03 In-Field Survey Setup*** use case assists a user in configuring or modifying a *field survey setup file* for a data collection device. The field survey setup file is an output from ***SM-02 Pre-Field Survey Setup.*** The ***SM-04 Collect Field Data Observations*** use case provides for the polling (reading) of observations from *measuring devices* such as a total stations, the storage of the observations, and reduction of the observations (i.e., mean of the observation sets, slope distance to horizontal, difference in elevations, etc.). ***SM-05 Perform COGO and Layout*** provides coordinate geometry functions.

Summary of Important Survey Management Use Case Terms

Research scope. Data to be investigated for a given project defined by spatial extent and source criteria. May include digital records and hardcopy records during a defined epoch. The sum total of the selected search parameters or the query including spatial extent.

Survey project. This is an organizational/system concept to represent a set of field activities. It's where and how all the relevant data and files are stored for future use. A Survey Project may be comprised of one or more *Field Surveys*.

Field survey setup file. A list of parameters and configurations for the setup of a *data collection device*. A file which contains the type of data to collect; geodetic vs. planar geometry; the hardware/communications parameters; the area of interest; setup instructions for custom in-field menus and data collection forms; paths to reference data (i.e. coverages), images, and documents; and the link from the Field Survey to its Survey Project.)

Data collection device. An instrument for digital storage of readings and information about those readings. Information may be manual or digital input. Typically a personal computer capable connected to a measurement device.

Field survey data set. The set of reference data transferred to a data collection device for use in the field (i.e. coverages, images and documents.) that pertains to a Survey Project.

Readings. A value taken from an arbitrary scale (chronometer, theodolite circle, compass, chain, etc.) returned by a measuring device. A measurement device's direct output of observations (i.e. circle readings, distance, etc.). This can vary depending on the type of measuring device.

Observation sets. A set of one or more readings from a measuring device (may be multiple observations for the same feature).

Measurements. The reduced and/or mean values of an observation set. The angular difference between readings, the distance, or the azimuth/bearing. See the appendices for a complete definition of a measurement.

1.4.2 Overview Of Measurement Management Use Cases

Concepts

The use cases for Measurement Management (MM) are intended to manage survey measurement and other geometric data in an automated environment. The inputs into the Measurement Management system are the following:

- **Measured bearings and distances** of lines from the Survey Management system, other digital sources, paper records and data attributes,
- **Measured geographic coordinates** of corners, as well as attributes,
- **Terrain-based boundaries** extracted from traditional map coverages, and
- **Rules of construction** for further division of land, as interpreted from legal records. Examples are offsets and PLSS section subdivision.

The purpose of Measurement Management is twofold. One purpose is to combine the individual components of measurement data from a variety of sources and reliabilities (pre-

adjusted measurement network) into a seamless and coherent network (adjusted measurement network). The second purpose is to further divide the network to its needed detail based on legal descriptions to form all the spatial features needed to display the known legal descriptions (legal description fabric).

The general steps (and use cases) included in Measurement Management are:

- Assemble all measured feature components for the adjustment area, including error estimates and data source descriptions. (System Utilities such as **Input** and **Import Data**; Use cases: ***MM-01 Construct Measured Feature, MM-03 Edit Measurement Data)***
- Perform least square adjustment/analysis, which includes automatic transforms of data to common units and projections. (Use case: ***MM-02 Adjust and Analyze Measurement Network***.)
- Inspect analysis results for anomalies that may indicate data entry blunders. Fix blunders. (Use cases: ***MM-03 Edit Measurement Data***.)
- Option: Inspect results of analysis on blunder-free data for clues to refine error estimates. (Use cases: ***MM-03 Edit Measurement Data***)
- Apply stored rules and further divide the network into pieces as interpreted from legal records. (Use case: ***SM-05 Perform COGO and Layout***.)
- Copy the results into the legal description fabric, overwriting what existed in the adjustment area.

Creating measurement networks with Measurement Management provides the foundation for the legal description and parcel fabric tiers. Integrated maintenance of cadastral data is made much more efficient when geometry can be shared. The measurement management functionality should assist in the interpretation of (1) the reliability of each point position and (2) where data editing is needed. Based on such an interpretation, new data can be added to the pool of measurement data and elements that no longer aid the optimal solution can be removed. Any area can be selected and adjusted, usually based on what point positions will be enhanced by the new data being added. New data, once attributed and verified as *blunder*-free, can be integrated into a seamless network.

Summary Of Important Measurement Management Use Case Terms

COGO Procedures. A unique set of Coordinate Geometry computations. In Measurement Management, the results of these computations are not subject to adjustment. The stored COGO procedures are reapplied to the Adjusted Measurement Network after each adjustment. These procedures are derived from interpretations of the rules of construction as laid out in legal records such as survey plats and deeds.

Error Estimate. A numeric value expressing the reliability of each piece of data in the pre-adjusted survey network. This value expresses the amount of adjustment that would be expected to occur during the least square adjustment and is used as a weighting to control the adjustment of better data. This value is usually applied consistently to distances, bearings and control coordinate values within each survey. The pre-adjustment estimates

are based on date, equipment and surveyor. The refinements to these estimates are based on the reports from the least square adjustment/analysis.

Least Square Adjustment/Analysis. A mathematical process that simultaneously combines all measurements in a dataset and adjusts their residuals to derive the optimum positional values as well as statistics that include the reliability of each derived value. A *Parametric Least Square Analysis/Adjustment* is a "weighted" least square adjustment, in that it considers the quality of data that varies throughout the data set.

Weight. Numeric values that are used to restrict the amount of adjustment of a measured value, based on the confidence in the measurement's reliability. A highly reliable measurement will have a small "error estimate" and is referred to as being "more weighted" than unreliable data.

1.4.3 Overview of Parcel Management Use Cases

Concepts

The use cases for Parcel Management (PM) are intended to describe the various business processes necessary to maintain land records in an automated environment. The first use case, ***PM-01 Verify Parcel***, outlines the various steps necessary in the original filing of a document (i.e., deed being recorded or application filed). ***PM-02 Construct Legal Description*** allows for creation and maintenance of current and historical legal descriptions. ***PM-03 Edit Legal Description Fabric*** allows for generation and maintenance of survey and non-survey descriptions and geometries in an integrated 'coverage' that are the building blocks for parcel legal descriptions. ***PM-05 Edit Parcel Fabric*** allows for building and attributing parcels necessary to maintain a 'coverage' based on a particular business practice (e.g., ownership, rights, and restrictions) in a user-defined geographic area.

There are certain key survey and mapping terms that must be understood in order to 'navigate' the Parcel Management use cases. Please reference the complete listing of definitions available within the appendix. A diagram is also included in this overview to help explain the relationship between the various measurement network and fabric 'layers.

Summary Of Important Parcel Management Use Case Terms

Legal description. The narrative and geometric description for a discrete area of land. Descriptions may be related to parcels (many-to-many) and to geometries.

Area Legal Description. (AKA Areal Reference)(e.g. geopolitical, PLS, Block-Lot, Mineral Survey, irrigation lots. Nominal; delimited in reference survey system having area taxonomy, nesting and division rules; discussion of 'tracting' and frameworks for spatial indexing)

Perimeter Legal Description. (Record boundary, metes and bounds, sequenced set of bearings and distances, strip description, adjoiner description, riparian or aquatic area description, reference calls to natural features {contour, ridgeline, watercourse})

Portion/Remainder Legal Description. (Area as a quantity {e.g. 'north sixty acres of...', 'the north four-hundred feet of…'}, exclusions; other reference calls; ambiguous areas that cannot be mapped relative to any reference).

Measurement Network. A set of topologically related measurements (coordinate points and lines) and constructions (area-based features, non-surveyed features). May be in various states of connectivity and adjustment.

Pre-Adjusted Measurement Network. Multiple coordinate values exist for some points, so lines which should be connected may not be (due to measurement errors).

Adjusted Measurement Network. All over-determined points have unique coordinates.

Legal Description Fabric. An adjusted measurement network to which constructions (terrain feature boundaries, non-survey data) have been added.

Parcel Fabric. A Legal Description Fabric that has been modified to represent parcel configuration for a specific business purpose (e.g. ownership parcels, tax parcels, historic parcels).

Parcel. A single cadastral unit, which is the spatial extent of the past, present, and future rights and interest in real property.

Parcel Legal Description. A composite description that contains all the *legal descriptions* that define a parcel and can be used to derive the full spatial extent of the parcel.

1.4.4 Overview of GeoCommunicator Use Cases

Concepts

The use cases for GeoCommunicator (GC) are intended to describe the various business processes necessary to search, access, and maintain spatial information in an Internet web-enabled environment. Spatial information, in the GeoCommunicator context, includes metadata, the data itself, and events pertaining to data, having a geographic component. The GeoCommunicator combines the concepts of Data Warehouse and Data Clearinghouse with the Field-to-Fabric concept in which events from raw data collection to final integrated data set may be identified and communicated. The initial focus of the GeoCommunicator site might be limited to the communication and exchange of data, events and information for the surveying community. However, it is intended that GeoCommunicator would grow to provide an implementation framework that would readily support numerous other data sets and information themes in the future.

The ***GC-01 Conduct Search*** and ***GC-02 Browse Search Results*** use cases provide tools for the Browser actor seeking spatial information. The Browser specifies the 'where' (spatial extent), the 'what' (data or event category), and the 'when' (time-frame) in a spatial query and views/downloads the results. This actor may become a Subscriber through the ***GC-07 Manage Subscriber Account*** use case where flags, defined by a spatial query, are set that trigger automatic notification (e-mail).

Actors intending to provide information apply through the ***GC-05 Manage Provider Account*** use case and, if approved, utilize tools and procedures described in the ***GC-06 Submit Data*** and ***GC-03 Submit Event*** use cases. Event Providers submit descriptions of planned activities, the location (spatial extent), and duration (calendar). Data Providers may submit spatial data (that meets content standards) to be integrated into seamless map themes. Data Providers may provide links to locally-stored data that does not meet the standard.

Where data from several Providers does not match, the areas of data discrepancy may be highlighted and targeted for resolution.

The ***GC-10 Post Comment*** use case provides for communication among GeoCommunicator actors. Browsers and Subscribers may join a topical forum or e-mail group. They may communicate with Providers concerning their data and events (identify errors, ask questions, etc.). They may post an Information Notice describing available information, but not accessible through the GeoCommunicator. They may post an Information Request (data call) for information not found through the ***GC-02 Browse Search Results*** process.

The remaining use cases are designed for an Administrator actor to manage accounts, to manage the on-site data and links to the off-site data, to monitor the events calendar, to trouble-shoot communication problems, and to maintain the GeoCommunicator web site.

Summary of Important GeoCommunicator Use Case Terms

Data. Any and all non-event information, regardless, of format or medium, that is searchable by GeoCommunicator users.

> ***Geo-Referenced***. Raster or vector data that contain world coordinates.
>
> ***Geo-Related.*** Data that is associated or linked to a point or area entity (spatial objects). Examples: Survey Plat of a township; Patents and deeds linked to a parcel by legal descriptions.
>
> ***Reference Document.*** Helpful technical information related to events or data. May have no direct relationship with a spatial data set (e.g., manuals, requests for information [RFIs], reports, etc.).
>
> Data may be packaged as a set of associated data elements from various categories. Data categories that have a spatial extent (footprint) can be displayed and searched for spatially. Categories of data include thematic layers, proposed layers, tabular reports, images, *reference documents*, *data discrepancies*, etc. Some *reference documents* may have no direct relationship with a specific spatial data set (e.g. manuals, RFIs, reports, etc.).

Event. Any activity, data submission, or communication that might trigger a *notification*.

> ***Activity Event.*** Any activity on the land submitted through the Submit Event (manual) process by the Event Provider. Example: Coordinate data collection with GPS equipment.
>
> ***Data Event.*** Any data submitted through the Submit Data process that automatically sets a flag to trigger a notification. Example: Data update (due to improved quality).
>
> ***Communication Event.*** Any creation of a discussion forum, email group, information notice, sending an email, or information call submitted through the Post Comment process.
>
> An activity event (e.g. data collection) may result in a data submission event.

Spatial Extent. Location on the ground (footprint). Includes any method for describing a point or area. Examples include Lat/Long, PLSS, minimum bounding rectangle, boundaries (admin, other).

1.5 Next Steps

The requirements and use cases documented in this report are only the first step in the overall NILS development process. The next steps in the NILS project will involve an iterative series of analysis, design, build and test tasks. Future NILS phases will be managed using MED and in compliance with the BLM architecture.